Dean for Research
Innovation Funds
2014 - 2020
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Executive Summary

The drive to explore is one of the qualities that defines us as humans. At Princeton, our faculty do more than simply follow a path; they take risks, set entirely new courses and make expeditions into unknown territories.

In today’s competitive funding atmosphere, the Dean for Research Innovation Funds provide support for high-risk, high-reward ideas that, without University funding, might otherwise not be explored. The funds enable Princeton researchers and scholars to follow their inspiration and intellect rather than following trends or sure bets. Since 2014, the program has supported a range of investigations across campus in the humanities, social sciences and natural sciences, as well as fostered collaborations between artists and scientists or engineers, and enabled new industrial collaborations to expand the frontiers of knowledge and tackle some of society’s greatest challenges.

By sparking discoveries, seeding the next generation of ideas, and forging opportunities, the Dean for Research Innovation Funds propel human journeys that exemplify the quality and vitality that is Princeton research.

PAULO G. DEBENEDETTI
DEAN FOR RESEARCH
CLASS OF 1950 PROFESSOR IN ENGINEERING AND APPLIED SCIENCE
PROFESSOR OF CHEMICAL AND BIOLOGICAL ENGINEERING
Far-reaching Impacts

Dean for Research Innovation Funds nurture a deep and broad range of outcomes, scholarship and discovery. These metrics are always growing, as the ideas planted by the innovation funds bear fruit.

53 funded research projects

109 scholarly publications

15 conferences, performances and exhibitions

7 patents pending or issued

The projects have created more than 120 educational and early-career opportunities.

64 undergraduate students

37 graduate students

20 postdoctoral researchers
Return on Investment

The investment of $7.9 M has laid the groundwork for significant subsequent external funding for research and innovation.

Dean for Research Innovation Fund investment

$7.9 Million

Subsequent funding from federal, foundation and corporate sponsors

$22.8 Million

Subsequent small-business funding

$5.9 Million
Selected Highlights

$10.75M in subsequent research funding from the U.S. Dept. of Energy

“A new approach to creating low-cost, light-activated catalysts for new chemical reactions led the U.S. Department of Energy to award $10.75M to launch Princeton’s Bioinspired Light-escalated Chemistry Energy Frontier Research Center.”

—NEW IDEAS IN THE NATURAL SCIENCES

“Funding that allows us to develop rapidly new technologies and ideas is of crucial importance to the innovation culture at Princeton.”

—ROBERT PRUD’HOMME, PROFESSOR OF CHEMICAL AND BIOLOGICAL ENGINEERING

Explore High-potential Concepts

Advance Disciplines

Researchers from Princeton, the African School of Economics and the Universidad de los Andes are combining econometrics with traditional research techniques to pioneer the emerging field of historical applied microeconometrics.

—NEW IDEAS IN THE SOCIAL SCIENCES
Spur Innovation
A startup based on nanoparticle encapsulation technology received second-round venture funding and collaborates with several pharmaceutical firms. Through a National Science Foundation small business grant, the company is working on a COVID-19 vaccine delivery platform.
— NEW INDUSTRIAL COLLABORATIONS

Promote Collaboration
A physicist and an art historian collaborated to design a next-generation X-ray fluorescence device for art conservation, and pioneered new imaging applications for subatomic particles called muons.
— COLLABORATIONS BETWEEN ARTISTS AND SCIENTISTS OR ENGINEERS

Enable Scholarship
An international collaborative project received support to make classical Chinese concepts accessible to a wide community of scholars.
— NEW IDEAS IN THE HUMANITIES
Seeding the Future

Recognizing that unconventional or untested ideas can be difficult to fund through conventional sources, the University created the Dean for Research Innovation Funds to make such explorations possible.

The program supports a broad range of intellectual inquiry across campus. In the sciences and engineering, the Innovation Funds enable laboratory experiments and theoretical or computational modeling, the results of which often inform successful subsequent proposals to external funding agencies. In the social sciences and humanities, the funds support faculty conferences, lecture series and other endeavors that catalyze new scholarship.

“Opportunities like these impact the quality of both the faculty members that we are able to attract to Princeton, and the research that they are able to do once here.”

—PABLO G. DEBENEDETTI, DEAN FOR RESEARCH, CLASS OF 1950 PROFESSOR IN ENGINEERING AND APPLIED SCIENCE, AND PROFESSOR OF CHEMICAL AND BIOLOGICAL ENGINEERING
Now in its seventh year, the program has demonstrated that these seed funds indeed return rewards that far exceed initial investments. Through 2020, the program has nurtured 53 projects that have led to many significant outcomes, including discoveries published in journal articles, books and monographs; new collaborations across disciplinary lines; exhibitions and performances; funded proposals to federal agencies; and invention disclosures and patents. These projects have impacts well beyond the University.

The initiative ensures not only that Princeton researchers are able to explore new horizons but also helps the University attract and retain talented and diverse faculty.

This report illustrates the numerous outcomes of the funded projects, from transformative findings that attract subsequent external investments in research to expansions of scholarship in entirely new directions.

With projects typically lasting one to two years, and outcomes taking months or years to publish, this report highlights projects started in the first few years of the program and ones that provide vivid examples of the program’s success.

Neurons grown on a scaffolding can act as bridges across damaged sections of the spinal cord. (*New Ideas in the Natural Sciences:* The Neuron Bridge: A Novel Platform Architecture, Jean Schwarzbauer, Jeffrey Schwartz)
Program Goals

- **Explore early-stage, high-potential concepts** and gather evidence for future funding proposals to research sponsors.

- **Advance disciplines and enable scholarship** through conferences, seminar series, digital resources, technologies and the exchange of ideas.

- **Spur innovation and discoveries** that have the potential to transform everyday life and benefit society.

- **Promote collaboration** to provide a rich cross-fertilization of ideas with synergistic outcomes.
Fund Categories

Five funding categories encourage exploration and creativity across a range of disciplines.

**New Ideas in the Natural Sciences**
supports the exploration of high-potential ideas that are at an early stage and therefore not ready to form the basis of a competitive proposal to an external funding agency. Faculty members in the Natural Sciences are eligible to request up to $100,000 per year for projects lasting up to two years, for a total of $200,000. A faculty committee evaluates the proposals with an eye towards enabling exploratory research.

**New Industrial Collaborations**
fosters research collaborations between industry and academia. Industry often plays an essential role in identifying interesting problems of societal relevance, bringing innovations to fruition, and making them available as devices or services. The awards support faculty members in the Natural Sciences or Engineering with up to $100,000 in the first year and $75,000 in the second year, with a requirement of a matching $75,000 contribution from an industry collaborator, for a total of up to $250,000 over two years.

**Collaborations Between Artists and Scientists or Engineers**
brings faculty members in the Arts and in the Natural Sciences or Engineering together to develop synergistic innovations. Through this fund, experts in seemingly unrelated fields exchange and expand their respective areas of knowledge in ways that benefit both disciplines. Investigators may request up to $75,000 per year for projects lasting up to two years, or $150,000 in total.

**New Ideas in the Humanities**
encourages innovative scholarship on original theories as well as enduring questions. Projects aim to advance the discipline through support for activities such as conferences, new collaborations and creative work. The awards provide a total of up to $50,000 for projects lasting up to two years.

**New Ideas in the Social Sciences**
promotes scholarship and explorations of society and human advancement. Support for the social sciences may include development of new research resources, data collection and analysis, and novel scholarly work. Awards provide a total of up to $50,000 for projects lasting up to two years.
Faculty Participation

Participation by members of the faculty occurs at all career stages. Eighty-one scholars — 20 assistant professors, 17 associate professors, 41 full professors and three other scholars — have received awards. (Career stage at time of award)

Participation occurs across Princeton’s four academic divisions: Natural Sciences, Engineering, Humanities and Social Sciences. Each space is sized proportionately to the number of principal investigators from each department. (Primary department at time of award)

<table>
<thead>
<tr>
<th>Natural Sciences</th>
<th>Humanities</th>
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<tbody>
<tr>
<td>Molecular Biology</td>
<td>English</td>
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<tr>
<td>Chemistry</td>
<td>Art and Archaeology</td>
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<tr>
<td>Physics</td>
<td>Art Museum</td>
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<tr>
<td>Ecology and Evolutionary Biology</td>
<td>Lewis Center for the Arts</td>
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<tr>
<td>LSI</td>
<td>COL</td>
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<td>PNI</td>
<td>EAS</td>
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<td>Psychology</td>
<td>German</td>
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<td>Music</td>
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<td>Engineering</td>
<td>Social Sciences</td>
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<td>Computer Science</td>
<td>Politics</td>
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<td>CBE</td>
<td>History</td>
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<td>MAE</td>
<td>Sociology</td>
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<tr>
<td>PRISM</td>
<td>ECO</td>
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GEO - Geosciences; COL - Comparative Literature; LSI - Lewis-Sigler Institute for Integrative Genomics; PNI - Princeton Neuroscience Institute; EAS - East Asian Studies; CBE - Chemical and Biological Engineering; MAE - Mechanical and Aerospace Engineering; PRISM - Princeton Institute for the Science and Technology of Materials; ECO - Economics.
Selection Process
Projects are awarded following a competitive application process that involves anonymous peer review by teams of Princeton faculty. Over 100 faculty members have participated as proposal reviewers.

Awards have been made to 53 of the 246 submissions across the five award categories, a funding rate of 22%.

Funding per Category
Since inception, the Dean for Research Innovation Fund program has awarded $7.89M across five fund categories. Two categories, New Ideas in the Natural Sciences and New Industrial Collaborations, typically support laboratory teams and equipment, and have distributed funds annually since 2014, and thus reflect larger overall fund distributions. The next three categories, Collaborations Between Artists and Scientists or Engineers, New Ideas in the Humanities, and New Ideas in the Social Sciences, have operated three of the last seven years, and have dispensed smaller award amounts consistent with the funding needs of research in these areas.
Awards and Outcomes

By unlocking the secrets of photosynthesis, researchers are harnessing light to carry out unprecedented chemical reactions. *(New Ideas in the Natural Sciences: Photo-induced Cross-coupling for Sustainable Chemical Synthesis: Harvesting Visible Light with Earth-abundant Catalysts, Abigail Doyle)*
NEW IDEAS IN THE NATURAL SCIENCES

The fund supports the exploration of ideas that have the potential for substantial impact on a field in the natural sciences, but that may be too preliminary to compete successfully for grants from funding agencies.

Note: Faculty titles are current as of date of this report, not the date of award.
Imaging the Universe's Origins

Observations of the Cosmic Microwave Background

The faint temperature fluctuations known as the cosmic microwave background have helped researchers determine the age of the universe and uncover new information about neutrinos, dark matter and dark energy.

Physicists Page and Staggs are using these signals to test the concept of cosmic inflation, in which the universe exponentially expanded from the Big Bang. The two collaborators paired in 2016 to apply for a Dean for Research Innovation Fund award to design a new type of receiver to measure extremely faint disturbances, nested within the cosmic microwave background, called B-modes. These are patterns of polarized electromagnetic energy thought to be produced by gravitational waves that emerged from the Big Bang. Finding them would provide strong evidence for the inflationary theory of the universe.

Detection of such faint signatures requires instruments that collect microwave-frequency light in a set of

“We are tackling fundamental questions about the universe. The funding gave us the ability to innovate and investigate new directions.”

—SUZANNE STAGGS, HENRY DEWOLF SMYTH PROFESSOR OF PHYSICS
Imaging the Universe's Origins

optics tubes. Each tube contains filters to select only the wavelengths of interest and lenses to focus the incoming radiation onto a single sensor. For maximum sensitivity, the instruments operate at a tenth of a degree above absolute zero.

With Dean for Research funding, the Princeton team explored various designs for a device called a cryogenic backplane that can simultaneously cool multiple optics tubes.

The team created a new design that offers flexibility because it separates the cryogenic unit from the optics tubes, allowing researchers to build the cryogenic units and plug in the optics tubes when ready. Page worked with a team of undergraduates to make detailed drawings and to discuss the feasibility of the designs with a major maker of scientific cryogenic instrumentation.

When Page and Staggs helped found a large collaboration that became the Simons Observatory, the Princeton team adjusted the design to become part of a complete telescope.

As a result, the Simons Observatory granted the team $1.3M in subsequent funding to expand the project and incorporate it into the Simons Observatory, which is under construction in Chile’s Atacama Desert.

The system has been validated to perform at temperatures down to 8 milliKelvin. Over the next year, detectors and optics will be added to prepare for its deployment to begin its search for B-modes.

“The Dean for Research Innovation Fund not only brought in subsequent funding but it also spurred nine undergraduates to explore experimental physics and has become the foundation of one graduate student’s dissertation work,” Page said.
With Dean for Research Innovation Fund support, Doyle and her team of graduate students and postdoctoral researchers identified catalysts that rely on far cheaper and more abundant elements such as nickel. They published the results in the *Journal of the American Chemical Society*. Their success helped establish a new U.S. Department of Energy-funded Energy Frontier Research Center on Bioinspired Light-escalated Chemistry (BioLEC), led by Doyle's collaborator, Gregory Scholes, Princeton's William S. Tod Professor of Chemistry. BioLEC will receive $10.75M over four years and supports numerous postdoctoral researchers and graduate students.

**Correlating Brain and Behavior**

**All-Neuron I/O in Freely Behaving Animals**

Leifer and Shaevitz built an instrument to track an organism’s movement while simultaneously observing the firing of its neurons. The team engineered the neurons of the worm *C. elegans* to become brighter in color when active, and employed a technique known as optogenetics to control the organism's movement by shining light on it. The research led to several publications, including one in the *Proceedings of the National Academy of Sciences*. Subsequent funding included a Simons Foundation award of $0.3M to support the development of the instrument, a New Innovator Award of $2.4M from the National Institutes of Health (NIH) to Andrew Leifer, and an NIH Exploratory/Developmental Research Grant Award of $0.5M with collaborators at the University of Pennsylvania.
Harmonizing African Wildlife and Livestock
DNA-based Characterization of Diet and Microbiome

Wildlife conservation and livestock production need not be at odds on the African savannah. To study the interdependencies among African livestock and wild animals, Pringle collected the animals' fecal matter, which reveals what the animals eat and how their gut bacteria aid digestion. Results from the studies of diet and microbiome composition of large herbivores led to 16 articles in peer-reviewed journals, including two papers in the journal Nature, papers in the journals Science and Proceedings of the National Academy of Sciences, and more than a dozen other peer-reviewed scientific publications. The work was also featured in a PBS NOVA documentary. The work further spurred creation of a number of resources — including DNA barcodes, which are unique signatures that can identify organisms — that have been made available for use by other researchers studying plants and animals in Africa, and arthropods and lizards in the Bahamas. The project provided subject matter for five undergraduate senior theses, and led to additional funding from the National Science Foundation, two private foundations, and Princeton’s High Meadows Environmental Institute.

Restoring Nerve Function
The Neuron Bridge: A Novel Platform Architecture

Severed nerves have little chance of spontaneous repair in part because nerve cells cannot regrow over the damaged area. Schwartz and Schwarzbauer and their teams created a “neuron bridge” — a biocompatible scaffold patterned with lengthwise stripes that serve as guides on which the nerve cells grow. They explored a variety of flexible materials for use in parts of the body that need to bend, such as the spinal cord. The findings enabled further funding from the New Jersey Commission on Spinal Cord Research and resulted in three patent applications. The neuron bridge is now being tested in animals by collaborators at the Mayo Clinic.
## All Awardees: New Ideas in the Natural Sciences

<table>
<thead>
<tr>
<th>Year Awarded</th>
<th>Principal Investigators</th>
<th>Project</th>
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<tbody>
<tr>
<td>2014</td>
<td>Joshua Shaeowitz &lt;br&gt; <em>Professor of Physics and the Lewis-Sigler Institute for Integrative Genomics</em>  &lt;br&gt; Andrew Leifer &lt;br&gt; <em>Assistant Professor of Physics and Neuroscience</em></td>
<td>All-Neuron I/O in Freely Behaving Animals</td>
</tr>
<tr>
<td>2014</td>
<td>Daniel Sigman &lt;br&gt; <em>Dusenbury Professor of Geological and Geophysical Sciences, Professor of Geosciences</em></td>
<td>Reconstructing Past Atmospheric Carbon Dioxide Concentrations</td>
</tr>
<tr>
<td>2014</td>
<td>Jean Schwarzbauer &lt;br&gt; <em>Eugene Higgins Professor of Molecular Biology</em>  &lt;br&gt; Jeffrey Schwartz &lt;br&gt; <em>Professor of Chemistry</em></td>
<td>The Neuron Bridge: A Novel Platform Architecture</td>
</tr>
<tr>
<td>2015</td>
<td>Zemer Gitai &lt;br&gt; <em>Edwin Grant Conklin Professor of Biology, Professor of Molecular Biology</em></td>
<td>Developing &quot;Resistance-resistant&quot; Antibiotic Strategies</td>
</tr>
<tr>
<td>2015</td>
<td>Jared Toettcher &lt;br&gt; <em>Assistant Professor of Molecular Biology</em>  &lt;br&gt; Alexander Ploss &lt;br&gt; <em>Associate Professor of Molecular Biology</em></td>
<td>Dissecting Signaling Complexity Using Cellular Optogenetics <em>In Vivo</em></td>
</tr>
<tr>
<td>2015</td>
<td>Gregory Scholes &lt;br&gt; <em>William S. Tod Professor of Chemistry</em>  &lt;br&gt; Garnet Chan &lt;br&gt; <em>(formerly A. Barton Hepburn Professor of Chemistry, now at Caltech)</em></td>
<td>New Chemical Reactions Through Many-particle Quantum Mechanics</td>
</tr>
<tr>
<td>2016</td>
<td>Suzanne Staggs &lt;br&gt; <em>Henry DeWolf Smyth Professor of Physics</em>  &lt;br&gt; Lyman Page &lt;br&gt; <em>James S. McDonnell Distinguished University Professor in Physics</em></td>
<td>Development of a Cryogenic Backplane for Observations of the Cosmic Microwave Background</td>
</tr>
<tr>
<td>2016</td>
<td>Robert Pringle &lt;br&gt; <em>Associate Professor of Ecology and Evolutionary Biology</em></td>
<td>DNA-based Characterization of Diet and Microbiome in African Wildlife and Livestock</td>
</tr>
<tr>
<td>2016</td>
<td>Mala Murthy &lt;br&gt; <em>Professor of Neuroscience</em>  &lt;br&gt; Lindy McBride &lt;br&gt; <em>Assistant Professor of Ecology and Evolutionary Biology and Neuroscience</em></td>
<td>Dissecting Mosquito Courtship Behaviors: Toward a Novel Intervention to Control Mosquito-borne Diseases</td>
</tr>
<tr>
<td>2017</td>
<td>Daniel Marlow &lt;br&gt; <em>Evans Crawford 1911 Professor of Physics</em>  &lt;br&gt; Thomas Gregor &lt;br&gt; <em>Professor of Physics and the Lewis-Sigler Institute for Integrative Genomics</em></td>
<td>Exploring Beta-decay-based Detection for Tracking Colonies of Self-organized Insects in 3D</td>
</tr>
<tr>
<td>2017</td>
<td>Abigail Doyle &lt;br&gt; <em>A. Barton Hepburn Professor of Chemistry</em></td>
<td>Photo-induced Cross-coupling for Sustainable Chemical Synthesis: Harvesting Visible Light with Earth-abundant Catalysts</td>
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All Awardees: New Ideas in the Natural Sciences *continued*

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<tr>
<th>Year Awarded</th>
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<th>Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017</td>
<td>Julien Ayyroles&lt;br&gt;Assistant Professor of Ecology and Evolutionary Biology and the Lewis-Sigler Institute for Integrative Genomics</td>
<td>The Turkana Project: The Genetic Footprints of Selection in Our Past May No Longer Fit Our Urban Lifestyle</td>
</tr>
<tr>
<td>2018</td>
<td>Ralph Kleiner&lt;br&gt;Assistant Professor of Chemistry</td>
<td>A &quot;Turn-on&quot; Fluorescent Probe to Visualize Interactions of the Anti-cancer Drug Cisplatin with Cellular RNA</td>
</tr>
<tr>
<td>2018</td>
<td>Salvatore Torquato&lt;br&gt;Lewis Bernard Professor of Natural Sciences, Professor of Chemistry and the Princeton Institute for the Science and Technology of Materials&lt;br&gt;Paul Steinhardt&lt;br&gt;Albert Einstein Professor in Science, Professor of Physics</td>
<td>Advances in the Design of 3D Disordered Photonic Solids</td>
</tr>
<tr>
<td>2018</td>
<td>Mohamed Abou Donia&lt;br&gt;Assistant Professor of Molecular Biology</td>
<td>An Unexpected Origin of Antibiotic Resistance</td>
</tr>
<tr>
<td>2019</td>
<td>Bridgett vonHoldt&lt;br&gt;Professor of Ecology and Evolutionary Biology&lt;br&gt;Andrea Graham&lt;br&gt;Professor of Ecology and Evolutionary Biology</td>
<td>Defending the Elephant Seal: Organismal Immunity to Species Conservation</td>
</tr>
<tr>
<td>2019</td>
<td>Nan Yao&lt;br&gt;Senior Research Scholar and Lecturer with the Rank of Professor in the Princeton Institute for the Science and Technology of Materials, Director of the Imaging and Analysis Center&lt;br&gt;Nieng Yan&lt;br&gt;Shirley M. Tilghman Professor of Molecular Biology</td>
<td>Novel Techniques for Applying Electric Field to Voltage-responding Membrane Proteins for Cryo-EM Analysis</td>
</tr>
<tr>
<td>2019</td>
<td>Alexander Todorov&lt;br&gt;Professor of Psychology</td>
<td>SocialGAN Generating Infinity Many Hyper-realistic Faces with a Simple Web Application</td>
</tr>
<tr>
<td>2020</td>
<td>Amit Singer&lt;br&gt;Professor of Mathematics and the Program in Applied and Computational Mathematics&lt;br&gt;Charles Fefferman&lt;br&gt;Herbert E. Jones, Jr. ’43 University Professor of Mathematics</td>
<td>Optimal Transportation Manifold Learning with Application to Structural Biology</td>
</tr>
<tr>
<td>2020</td>
<td>Ricardo Mailaro&lt;br&gt;Assistant Professor of Molecular Biology</td>
<td>Functional Evolution of Antimicrobial Peptides in Marsupials</td>
</tr>
<tr>
<td>2020</td>
<td>Lisa Boulanger&lt;br&gt;Associate Professor of Neuroscience</td>
<td>Lowering Barriers to Gene Therapy</td>
</tr>
</tbody>
</table>
NEW INDUSTRIAL COLLABORATIONS

Industry can play an essential role in research by helping identify challenges of relevance to society and by aiding the transformation of discoveries into technologies and devices for the benefit of humanity.
Deep learning, a powerful machine learning technique, is revolutionizing the ability to find patterns within large data sets. Neuroscientist Seung and computer scientist Li have applied deep learning to one of the most complicated problems in neuroscience: identifying and tracing the connections of individual neurons.

The challenge was how to use deep learning efficiently to identify neurons from thousands of ultra-high resolution 3D electron microscopy images.

To make sense of the vast data in these images, the team turned to computers with multiple cores, or processors. The researchers teamed with Intel Corporation to use Intel’s multi- and many-core processors, as well as field-programmable gate arrays, which allow rapid and custom reprogramming of cores to optimize them for various tasks.

The researchers created an open-source software package, which is now available to the broader research community, and they are using it to create three-dimensional maps of the brain.

Sebastian Seung
Evnin Professor in Neuroscience, Professor of Computer Science and Neuroscience

Kai Li
Paul M. Wythes ’55 P86 and Marcia R. Wythes P86 Professor in Computer Science

Industry Partner:
Intel Corporation
Deep Decarbonization of the Grid
Addressing the Challenge of Intermittent Renewable Electricity

Eric Larson
Senior Research Engineer, Andlinger Center for Energy and the Environment

As solar and wind power grow, new market designs are needed to incentivize innovation among power generators to balance the variability of renewable sources. To explore the energy marketplace in the era of renewable power, Larson and colleagues in the Andlinger Center for Energy and the Environment teamed with industry collaborator NRG Energy, the nation’s largest competitive power producer. The team developed the Extended Electricity Market Simulation Tool to investigate alternative electricity pricing mechanisms that incentivize power generators while also prioritizing decarbonization. The project gained additional funding from the Andlinger Center and led to four publications as well as to informal discussions with a range of stakeholders including regulators and grid operators in New Jersey and across the nation. The work also led to two follow-on projects funded by Public Service Enterprise Group and Community Solar.

Ramping Up Biofuel Production
Novel Block Copolymers for Butanol Pervaporation Membranes

Richard Register
Eugene Higgins Professor of Chemical and Biological Engineering

Industry Partner: NRG

Butanol is a promising biofuel made via fermentation by organisms such as yeast or bacteria, but yield is limited because the biofuel can in turn poison the organisms that produce it. Register and his team collaborated with Promerus, LLC, a company that manufactures specialty polymers, to produce polymers that filter butanol from water. The researchers explored novel polymers and evaluated how different polymer compositions influenced the selectivity of the filters, producing materials superior in both selectivity and flux to state-of-the-art commercial membranes. The project provided the basis for two senior theses and led to four peer-reviewed publications.
Improving Connections

Miniaturization of the Optical Interference Cancellation System

Paul Prucnal
Professor of Electrical and Computer Engineering

Industry Partner: L-3 Communications Telemetry-East

As mobile and internet-enabled devices continue to grow in popularity, so does the demand for wireless connectivity. To boost the amount of data that can travel on wireless channels, Prucnal collaborated with L-3 Communications Telemetry-East to develop an inexpensive photonic integrated circuit for sending and receiving wireless transmissions. The advantages of photonic circuits over electronic hardware include greater speed, reduced interference, and the potential to double the amount of signals traveling between transmitter and mobile device. With L-3, the team integrated photonic capabilities with control circuitry and other features in a single device, greatly reducing the cost of the manufacturing, packaging and assembly. The project led to a patent as well as nearly $5.9M of further investment from industrial collaborators and from federal Small Business Innovation Research grants.

Targeted Delivery of Biologic Drugs

Surface Characterization and Binding Affinity of Single Nanoparticles Using NanoTweezers

Robert Prud’homme
Professor of Chemical and Biological Engineering

Industry Partners: OptoFluidics Inc. and Optimeos Life Sciences Inc.

Biologics are promising as therapeutics but are subject to rapid degradation in the body. Prud’homme and his team, in partnership with Philadelphia-based OptoFluidics Inc., examined a technology for encapsulating drugs in nanoparticles using the company’s state-of-the-art analysis device, the NanoTweezer. Prud’homme also worked with startup Optimeos Life Sciences Inc. to develop an encapsulation technology for peptides and proteins. The work led to two patent applications and several publications, and enabled Optimeos to raise second-round venture funding. The project also led to collaborations with Merck & Co., Duke University, Eli Lilly, Genentech, the University of Colorado, and MedImmune. Optimeos has contributed $300,000 to fund additional research by Prud’homme, two postdoctoral researchers and two graduate students. One graduate student has now become Optimeos’ chief scientific officer, and in 2020 Prud’homme was honored as the inaugural recipient of the Dean for Research Award for Distinguished Innovation.
### All Awardees: New Industrial Collaborations

<table>
<thead>
<tr>
<th>Year Awarded</th>
<th>Principal Investigators and Corporate Partner</th>
<th>Project</th>
</tr>
</thead>
</table>
| 2014         | Paul Prucnal  
Professor of Electrical and Computer Engineering  
L-3 Communications Telemetry East | Miniaturization of the Optical Interference Cancellation System |
| 2014         | Richard Register  
Eugene Higgins Professor of Chemical and Biological Engineering  
Promerus, LLC | Novel Block Copolymers for Butanol Pervaporation Membranes |
| 2015         | Kai Li  
Paul M. Wythes ’55 P86 and Marcia R. Wythes P86 Professor in Computer Science  
Sebastian Seung  
Evinrude Professor in Neuroscience, Professor of Computer Science and Neuroscience | Accelerating High-dimensional Deep Learning on Emerging Platforms: Multicore, Manycore and CPU-FPGA |
| 2015         | Robert Prud’homme  
Professor of Chemical and Biological Engineering  
OptoFluidics and Optimeos Life Sciences | Surface Characterization and Binding Affinity of Single Nanoparticles Using NanoTweezers |
| 2016         | Nick Feamster  
Visiting Research Scholar (formerly Professor of Computer Science, now at the University of Chicago)  
Comcast Corporation | Securing the Internet of Things in Broadband Access Networks |
| 2017         | Eric Larson  
Senior Research Engineer, Andlinger Center for Energy and the Environment  
NRG Energy | Deep Decarbonization of the Grid: Addressing the Challenge of Intermittent Renewable Electricity |
| 2017         | Robert Tarjan  
James S. McDonnell Distinguished University Professor of Computer Science  
Microsoft | New Algorithms for Content-serving Systems |
| 2017         | Aarti Gupta  
Professor of Computer Science  
Sharad Malik  
George Van Ness Lothrop Professor in Engineering, Professor of Electrical and Computer Engineering  
Amazon Web Services | Security Verification |
| 2018         | Mohammad Seyedsayamdost  
Associate Professor of Chemistry  
Johnson & Johnson | Discovering New Targets in *P. acnes*, the Causative Agent of the Skin Disorder Acne |
| 2019         | Adam Finkelstein  
Professor of Computer Science  
Adobe Research | Machine Learning to Assess the Quality of Recorded or Synthetic Speech |
AI provides the latest word in clearer audio

A new method developed by researchers at Princeton University could improve the listening experience for podcasts and other audio applications. Using an artificial intelligence (AI) approach known as deep learning, Professor of Computer Science Adam Finkelstein and his team developed a technique to transform low-quality recordings of human speech, approaching the crispness and clarity of a studio-recorded voice. (New Industrial Collaborations: Machine Learning to Assess the Quality of Recorded or Synthetic Speech, Adam Finkelstein)
COLLABORATIONS BETWEEN ARTISTS AND SCIENTISTS OR ENGINEERS

Collaborations Between Artists and Scientists or Engineers brings faculty in seemingly unrelated fields together to expand their respective domains of knowledge in ways that benefit both disciplines.
Collective animal motion — from flocking birds to schooling fish — is inspirational to artists and intriguing to scientists and engineers. Leonard, Marshall and Trueman led the exploration of improvisational structures involving networks of decision-making agents in Flock Logic, a project where dancers communicated via visual cues.

With Dean for Research Innovation Funds, the researchers extended their explorations, engaging a postdoctoral researcher to work at the intersection of engineering and compositional experimentation in dance and music. The study allowed for the emergence of synchrony and pattern, and explored the role of human bias and uncertainty. The work resulted in a journal publication as well as a number of workshops and performances. These included a workshop with vocalists that explored rhythms emerging from feedback patterns and performance rules using a cyclic leader-follower network topology; a movement and music flocking simulation computational tool developed by an undergraduate; and a dance installation created with neurodiverse collaborators that promotes interpersonal synchrony and a meditative space.
Two professors from different sides of campus came together to propose applying a technique involving subatomic particles called muons to the study of how ancient artifacts were made. Bagley and Tully explored using muons to probe the manufacture of Chinese Bronze Age vessels and bells.

Muons can travel through walls and have been used to search for hidden chambers in Egyptian pyramids. The Princeton team proposed that the muons’ ability to travel through objects could provide art historians a way to see inside the bronze walls of the ancient vessels. The researchers designed a novel imaging technique using accelerator-produced muon beams and published a roadmap for building the device.

As part of the project, the Princeton Art Museum acquired a high-precision X-ray fluorescence (XRF) spectrometer, and Tully worked with the museum to analyze a number of objects and paintings in the University collection. The team also held a joint Princeton-Yale workshop to highlight the use of XRF measurements to identify materials used in the process behind historic photographs, and developed course material that brings sophomore physics students to the Art Museum to learn about conservation work. In addition, the researchers designed a next-generation XRF device that leverages superconducting sensors and 2D imaging methodologies to provide higher precision for material identification. Tully, in collaboration with Princeton Plasma Physics Laboratory scientist Charles Gentile, has filed a patent application for the device.

**Seeing Through Walls**

**Ancient Art and the Higgs Boson**

Christopher Tully
Professor of Physics

Robert Bagley
Professor of Art and Archaeology, Emeritus
All Awardees: Collaborations Between Artists and Scientists or Engineers

<table>
<thead>
<tr>
<th>Year Awarded</th>
<th>Principal Investigators</th>
<th>Project</th>
</tr>
</thead>
</table>
| 2014         | Robert Bagley  
Professor of Art and Archaeology, Emeritus  
Christopher Tully  
Professor of Physics  | Ancient Art and the Higgs Boson                                                           |
| 2014         | George Scherer  
William L. Knapp ’47 Professor of Civil Engineering, Emeritus; Professor of Civil and Environmental Engineering and the Princeton Institute for the Science and Technology of Materials, Emeritus  
James Steward  
Nancy A. Nasher-David J. Haemisegger, Class of 1976, Director, Princeton University Art Museum; Lecturer with the Rank of Professor in Art and Archaeology  | Creative Matter, Materials Science, Environmental History and the Sustainability of Art   |
| 2014         | Naomi Leonard  
Edwin S. Wilsey Professor of Mechanical and Aerospace Engineering  
Susan Marshall  
Professor of Dance in the Lewis Center for the Arts  
Daniel Trueman  
Professor of Music  | Flock Logic with Sound and into Three Dimensions                                          |
| 2017         | Satish Myneni  
Professor of Geosciences  
James Steward  
Nancy A. Nasher-David J. Haemisegger, Class of 1976, Director, Princeton University Art Museum; Lecturer with the Rank of Professor in Art and Archaeology  | Did Widespread Toxic Metal Exposure Play an Important Role in the Collapse of Maya Civilization? |
| 2017         | Branko Glišić  
Associate Professor of Civil and Environmental Engineering  
Michael Koortbojian  
M. Taylor Pyne Professor of Art and Archaeology  | Integrative Technology for Holistic Analysis of Heritage Structures                      |
| 2017         | Adam Finkelstein  
Professor of Computer Science  
Thomas Levin  
Associate Professor of German  | Media Archaeology and the Science of Optical Audio Capture: Recovering the Forgotten Sonorine Archive of Vocal Performance, 1905-1907 |
| 2020         | Sigrid Adriaenssens  
Associate Professor of Civil and Environmental Engineering  
Rebecca Lazier  
Senior Lecturer in Dance in the Lewis Center for the Arts  | NODES - Net Topology and Dance Exploration Systems                                         |
| 2020         | Eduardo Cadava  
Professor of English  
John Higgins  
Associate Professor of Geosciences  
Mark Zondio  
Associate Professor of Civil and Environmental Engineering  | Exposure                                                                                 |
NEW IDEAS IN THE HUMANITIES

New Ideas in the Humanities encourages innovation and scholarship on enduring questions through the development of new collaborations and conversations or a major piece of scholarly work.
Commonly viewed as a period when the West developed new intellectual and cultural institutions, the Enlightenment also included changes in the Middle East, Asia Pacific and other regions of the world. Gee and Rivett convened the Global Enlightenment Project at Princeton to bring together leading scholars from around the world to explore the Enlightenment’s lasting global impacts on religion, race, and geographic and cultural diversity.

The scholars convened a major international conference, a graduate student mentoring session with renowned scholars of the eighteenth century, guest lectures, an interdisciplinary symposium on the secular, an interdepartmental lecture, and a one-day symposium.

The conference focused on the roles of conflicts within Christianity and among other major world religions, and global exchange, in constructing the Enlightenment period and beyond. The project garnered additional support from the Humanities Council and the Department of History.

This work spurred Gee to launch the Mindful Humanities Project, which applies the skills and disciplines of mindfulness to create new approaches to teaching and scholarship in the humanities. The English department plans to hire an expert in global and indigenous literatures, which the researchers trace to the Dean for Research Innovation Fund support and its role in raising awareness about the Global Enlightenment.
All Awardees: New Ideas in the Humanities

<table>
<thead>
<tr>
<th>Year Awarded</th>
<th>Principal Investigators</th>
<th>Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>Martin Kern</td>
<td>Migrating the <em>Thesaurus Linguae Sericae</em> to Princeton</td>
</tr>
<tr>
<td></td>
<td>Joanna and Greg Zeluck '84 P13 P18 Professor in Asian Studies,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Professor of East Asian Studies</td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>Sarah Chihaya</td>
<td>The Contemporary: Literature in the Twenty-first Century</td>
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<tr>
<td></td>
<td>Assistant Professor of English</td>
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<tr>
<td></td>
<td>Joshua Kotin</td>
<td></td>
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<tr>
<td></td>
<td>Associate Professor of English</td>
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<tr>
<td></td>
<td>Kinohi Nishikawa</td>
<td></td>
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<tr>
<td></td>
<td>Associate Professor of English and African American Studies</td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td>Sophie Gee</td>
<td>The Global Enlightenment</td>
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<tr>
<td></td>
<td>Associate Professor of English</td>
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<tr>
<td></td>
<td>Sarah Rivett</td>
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<tr>
<td></td>
<td>Professor of English and American Studies</td>
<td></td>
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<tr>
<td>2019</td>
<td>Wendy Belcher</td>
<td>Early African Literature Project: <em>Kebra Nagast</em> Translation</td>
</tr>
<tr>
<td></td>
<td>Professor of Comparative Literature and African American Studies</td>
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</tr>
<tr>
<td>2019</td>
<td>Joshua Kotin</td>
<td>The Shakespeare and Company Project</td>
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<tr>
<td></td>
<td>Associate Professor of English</td>
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Finding the Lost Generation through Shakespeare and Co.

An interactive website provides scholars and the public with insights into the Lost Generation, a group of writers and artists that came of age during World War I. The project, initiated with funding from a David A. Gardner ’69 Magic Grant, is based on records housed at the Princeton University Library from Shakespeare and Company, an English-language book shop and lending library in Paris. During the 1920s and ’30s, writers such as Ernest Hemingway, Gertrude Stein, and others borrowed and purchased books from the shop. (*New Ideas in the Humanities: The Shakespeare and Company Project, Joshua Kotin*)
NEW IDEAS IN THE SOCIAL SCIENCES

New Ideas in the Social Sciences encourages scholarship and innovation through conferences, technologies or expanded access to research resources.
In a world of interdependent systems — in finance, technology, trade and agriculture — a failure in one area has the potential to set off a cascade of failures across multiple areas. To explore historical collapses and gain insights that can prevent future catastrophes, Centeno led an initiative to bring together scholars from within the University and from around the world to discuss historical systemic collapse.

The multidisciplinary workshop attracted sociologists, historians, biologists, computer scientists, writers and filmmakers to share ideas through presentations, panel discussions and free-ranging conversations. The workshop led to the development of a website that collected the presentation slides, videos, readings and materials contributed by attendees. Several papers based on the conference are in the works and the results have been presented in a broad array of settings in the United States and Europe.

The team received subsequent funding from the Office of the Provost to create a global network of universities and researchers.

Centeno worked with the Princeton Institute for International and Regional Studies (PIIRS) Global Systemic Risk research community, which Centeno leads, to disseminate the knowledge from the workshop to wider audiences through the website, email lists and an article in British newspaper The Guardian. The team has also initiated work on a special issue for the journal Global Perspectives, and is preparing a book manuscript to be published by Routledge Press in 2021.
All Awardees: New Ideas in the Social Sciences

<table>
<thead>
<tr>
<th>Year Awarded</th>
<th>Principal Investigators</th>
<th>Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018</td>
<td>Jennifer Rampling</td>
<td>Through a Glass Darkly: Depicting Alchemical Change, 1400-1700</td>
</tr>
<tr>
<td></td>
<td>Miguel Centeno</td>
<td>Workshop on Historical System Collapse</td>
</tr>
<tr>
<td>2019</td>
<td>Andy Guess</td>
<td>Do Online Video Personalization Algorithms Polarize Users?</td>
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<tr>
<td></td>
<td>Dean Knox</td>
<td>Street Police Patrols and Crime Against Women in Public Space</td>
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<tr>
<td></td>
<td>Brandon Stewart</td>
<td>Resilience: A Psycho-ecological History</td>
</tr>
<tr>
<td>2019</td>
<td>Maria Vladi Sviatschi</td>
<td>Street Police Patrols and Crime Against Women in Public Space</td>
</tr>
<tr>
<td>2020</td>
<td>Katja Guenther</td>
<td>Resilience: A Psycho-ecological History</td>
</tr>
<tr>
<td>2020</td>
<td>Leonard Wantchekon</td>
<td>New Advances in Historical Applied Microeconomics</td>
</tr>
</tbody>
</table>

“Because of the Innovation Fund, Princeton University is seen as a leader in what is becoming a very important subfield within many disciplines.”

—MIGUEL CENTENO, MUSGRAVE PROFESSOR OF SOCIOLOGY, PROFESSOR OF SOCIOLOGY AND PRINCETON SCHOOL OF PUBLIC AND INTERNATIONAL AFFAIRS
Unlocking the secrets of the Sonorines

Researchers are working to develop a new technology for reading very old audio data stored in postcards known as Sonorines, which were popular from 1905 to 1907. The postcard’s reverse side contains an inscribed audio message playable with a phonograph-like device, but the surviving cards are too fragile to be played on the few existing players. (Collaborations Between Artists and Scientists or Engineers: Media Archaeology and the Science of Optical Audio Capture: Recovering the Forgotten Sonorine Archive of Vocal Performance, 1905-1907, Adam Finkelstein, Thomas Levin)
In the Nation’s Service and the Service of Humanity

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Back cover, clockwise from top left:
Researchers track the habits of African wildlife through what they leave behind. (New Ideas in the Natural Sciences: DNA-based Characterization of Diet and Microbiome, Robert Pringle)

A collaboration with industry yields highly energy-efficient photonic processors. (New Industrial Collaborations: Miniaturization of the Optical Interference Cancellation System, Paul Prucnal)

A historian explores the golden age of alchemy through allegorical imagery. (New Ideas in the Social Sciences: Through a Glass Darkly: Depicting Alchemical Change, 1400-1700, Jennifer Rampling)

A special journal issue asks what it means to be contemporary. (New Ideas in the Humanities: The Contemporary: Literature in the Twenty-first Century, Sarah Chihaya, Joshua Kotin, Kinohi Nishikawa)

The materials of early American art reveal the nation's environmental history as part of the major art exhibition Nature's Nation. (Collaborations Between Artists and Scientists or Engineers: Creative Matter, Materials Science, Environmental History and the Sustainability of Art, George Scherer, James Steward)
Learn more about the projects supported by the Dean for Research Innovation Funds at research.princeton.edu/funding.